United States Patent [19]

Samuels et al.

[11] **Patent Number: 5,065,173**

[45] **Date of Patent: Nov. 12, 1991**

[54] **PROCESSOR WITH SPEED INDEPENDENT FIXED FILM SPACING**

[75] Inventors: **James T. Samuels; Roger D. Ellsworth,** both of Rochester, N.Y.

[73] Assignee: **Eastman Kodak Company,** Rochester, N.Y.

[21] Appl. No.: **495,867**

[22] Filed: **Mar. 19, 1990**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 494,647, Mar. 16, 1990, Pat. No. 4,994,837.

[51] **Int. Cl.**[5] **G03D 3/08**

[52] **U.S. Cl.** **354/298;** 354/322

[58] **Field of Search** 354/298, 319, 320, 321, 354/322

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,057,817	11/1987	Korb et al.	354/298
4,300,828	11/1981	Kaufman	354/322

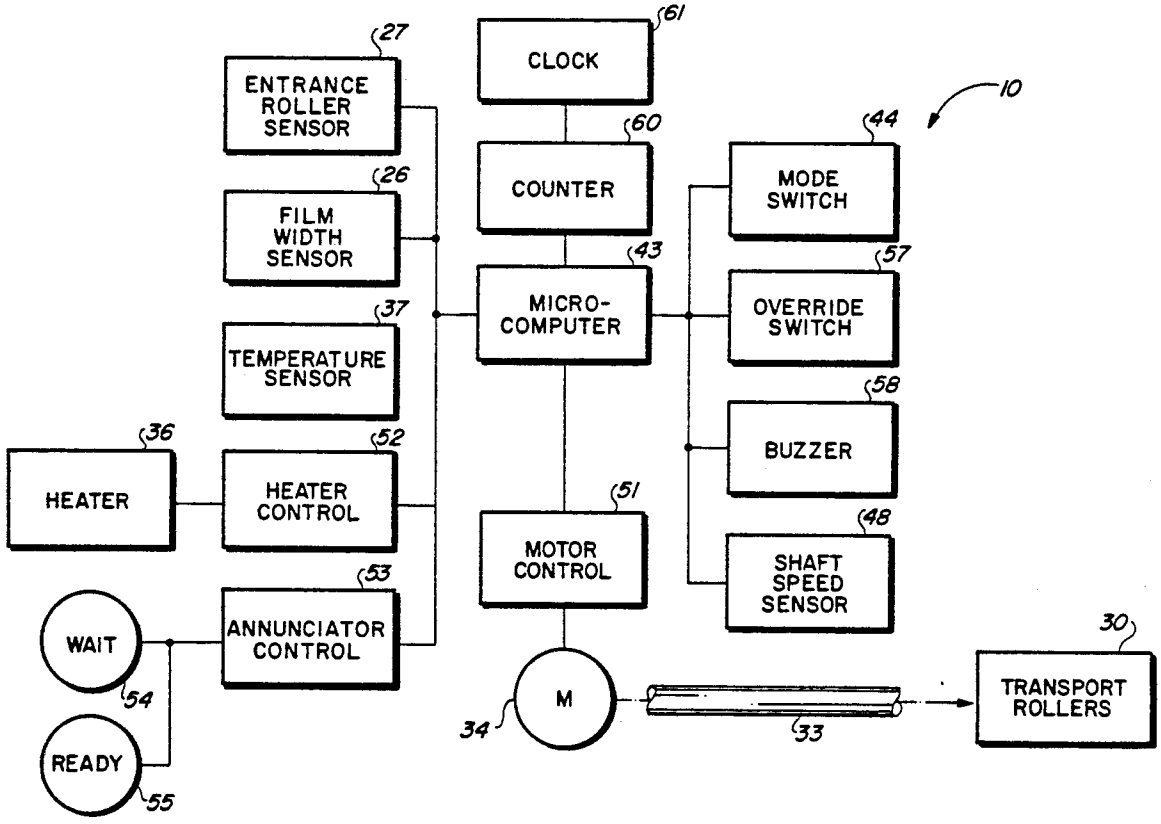
Primary Examiner—A. A. Mathews

Attorney, Agent, or Firm—G. Herman Childress

[57] **ABSTRACT**

An automatic film processor sets new reference developer chemical temperatures and film transport speeds in accordance with user input at a keypad and establishes a new delay time to provide constant fixed spacing along the transport path between trailing edge of one film sheet and leadfing edge of a next film sheet regardless of transport speed. "Wait" and "ready" lights are controlled to signal when a next sheet is to be fed. A microcomputer calculates the delay time and loads a counter. A buzzer signals countdown to zero.

14 Claims, 3 Drawing Sheets



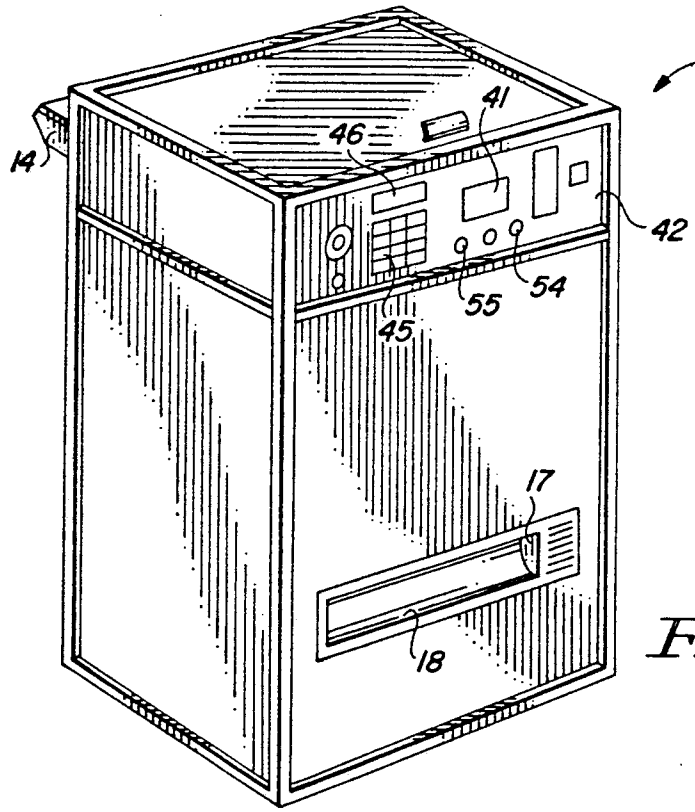
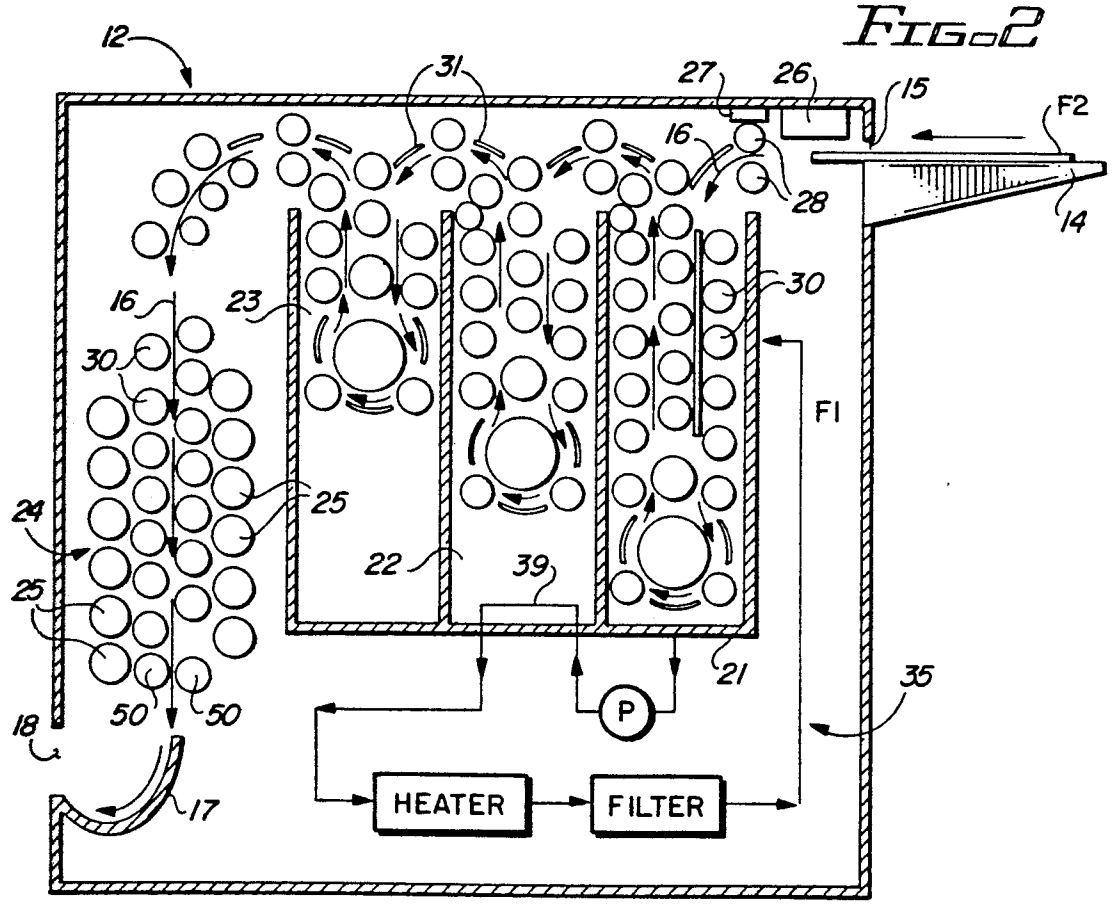

12
41
46
14
42
55
54
45
17
18

FIG. 1

FIG. 2


12
31
27
26
15
F2
16
28
14
16
23
30
30
F1
24
25
25
22
39
21
35
18
50
50
P
17
HEATER
FILTER

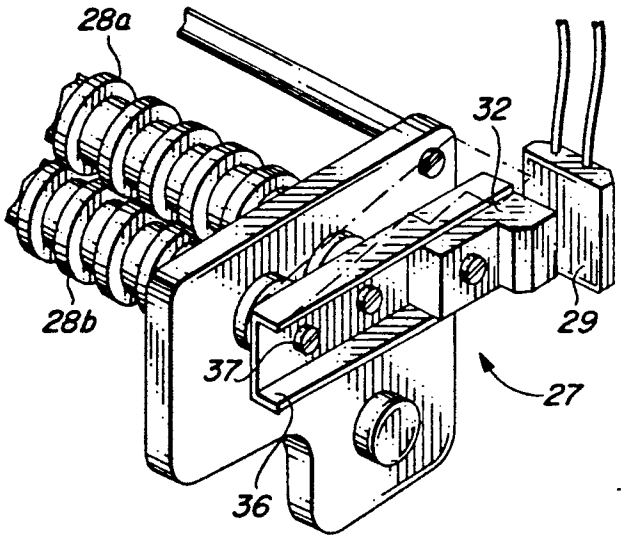

28a
32
28b
29
37
27
36

FIG. 3

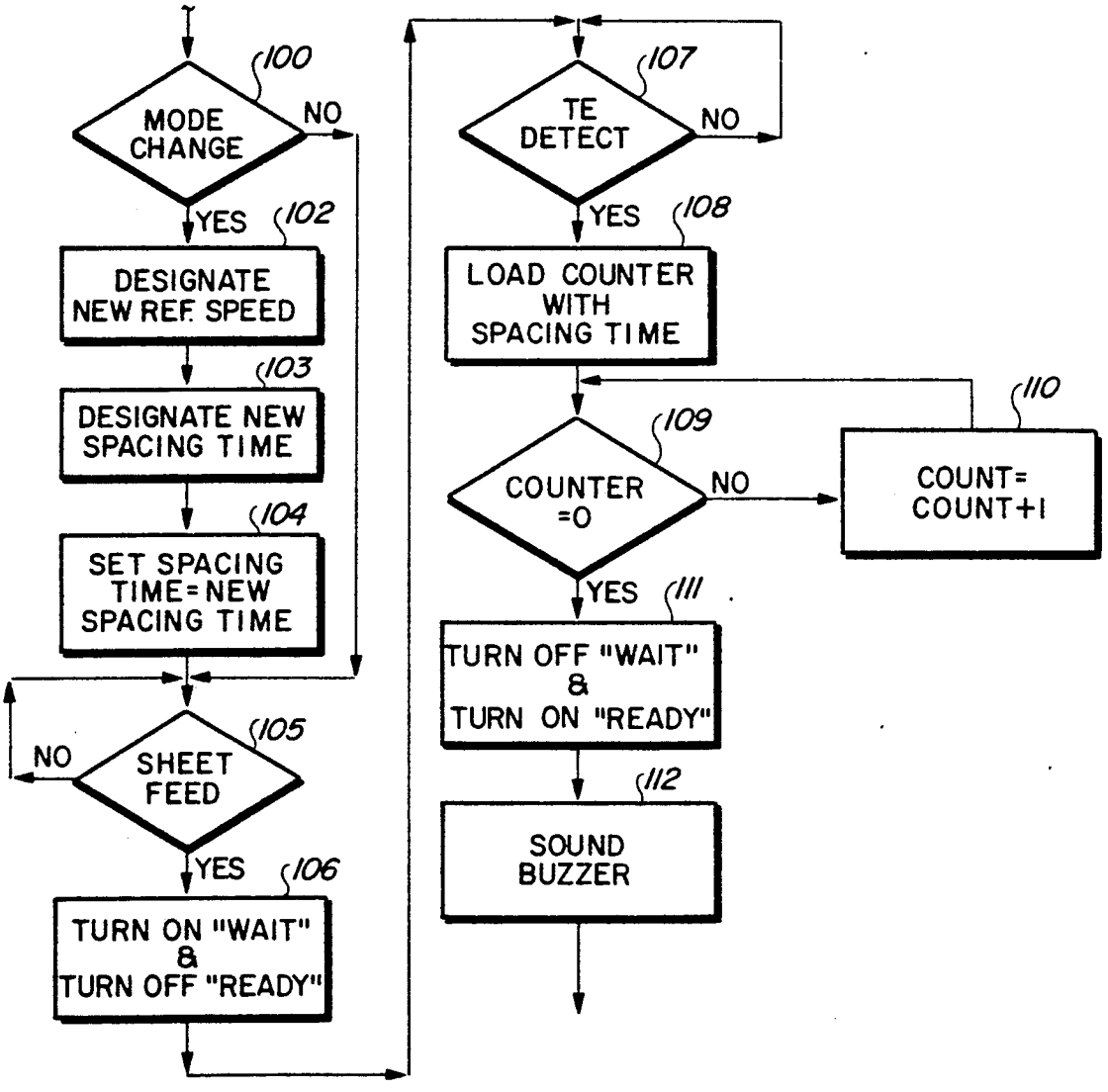

100
MODE CHANGE
NO
YES
102
DESIGNATE NEW REF. SPEED
103
DESIGNATE NEW SPACING TIME
104
SET SPACING TIME=NEW SPACING TIME
105
NO
SHEET FEED
YES
106
TURN ON "WAIT" & TURN OFF "READY"
107
TE DETECT
NO
YES
108
LOAD COUNTER WITH SPACING TIME
109
COUNTER =0
NO
110
COUNT= COUNT+1
YES
111
TURN OFF "WAIT" & TURN ON "READY"
112
SOUND BUZZER

FIG. 5

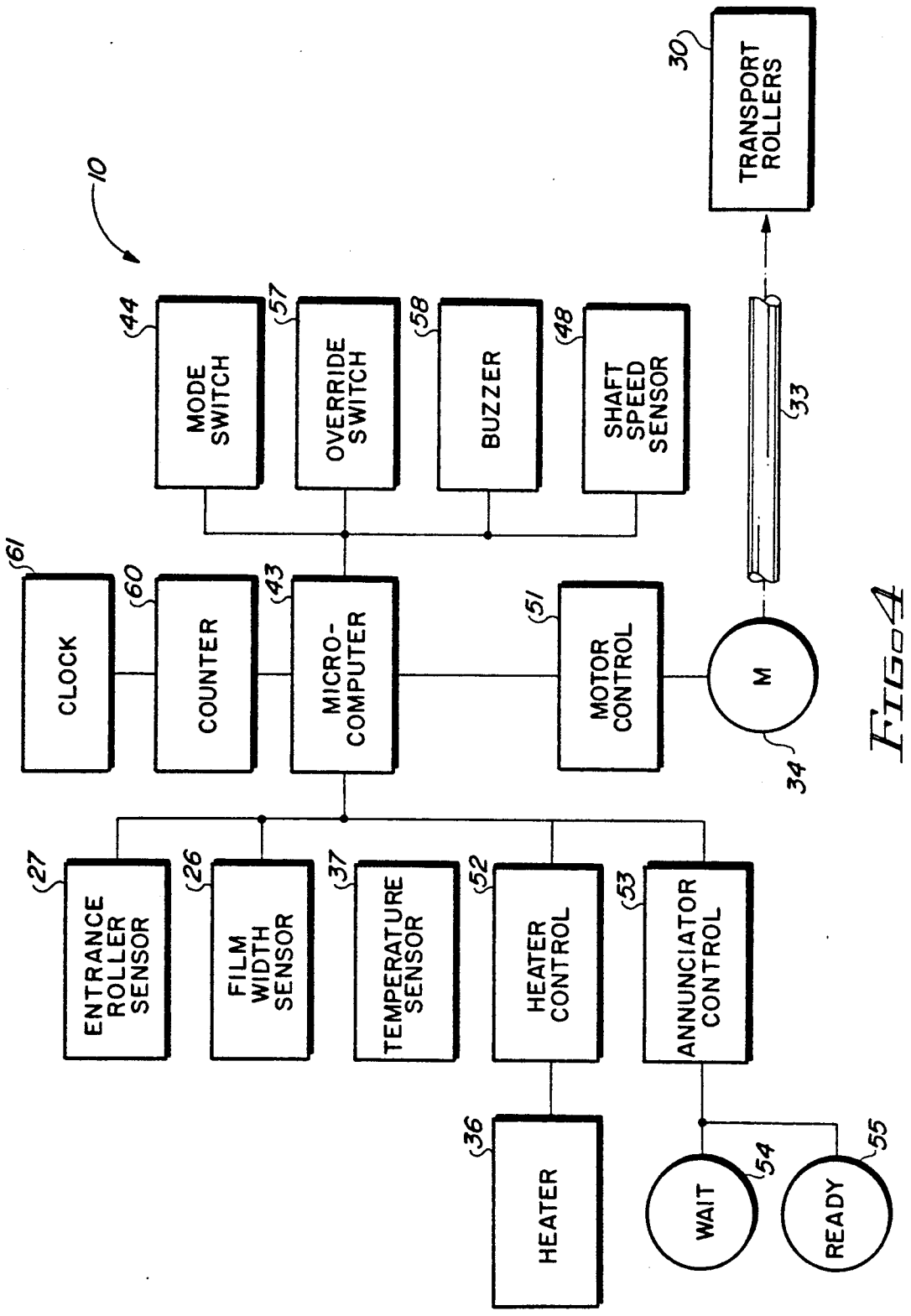

10
30
TRANSPORT ROLLERS
44
MODE SWITCH
57
OVERRIDE SWITCH
58
BUZZER
48
SHAFT SPEED SENSOR
33
61
CLOCK
60
COUNTER
43
MICRO-COMPUTER
51
MOTOR CONTROL
M
34
27
ENTRANCE ROLLER SENSOR
26
FILM WIDTH SENSOR
37
TEMPERATURE SENSOR
52
HEATER CONTROL
53
ANNUNCIATOR CONTROL
36
HEATER
54
WAIT
55
READY

FIG. 4

PROCESSOR WITH SPEED INDEPENDENT FIXED FILM SPACING

This is a continuation-in-part of commonly owned, copending U.S Pat. application Ser. No. 07/494,647, filed Mar. 16, 1990, now U.S. Pat. No. 4,994,837, entitled "Processor With Temperature Responsive Film Transport Lockout."

BACKGROUND OF THE INVENTION

The present invention relates to processors of film and similar photosensitive media, in general; and, in particular, to a processor having means to vary transport speed and including means to maintain fixed inter-film spacing regardless of transport speed.

Photosensitive media processors, such as the Kodak X-OMAT processors, are useful in applications such as the automatic processing of radiographic films for medical imaging purposes. The processors automatically transport sheets or webs of photosensitive film, paper or the like (hereafter "film") from a feed end of a film transport path, through a sequence of chemical processing tanks in which the media is developed, fixed, and washed, and then through a dryer to a discharge or receiving end. The processor typically has a fixed film path length, so final image quality depends on factors including transport speed which determines length of time the film strip is in solution, and the temperature and composition of the processing chemicals (the processor "chemistry").

In a typical automatic processor of the type to which the invention relates, film transport speed is set at a constant rate and the chemistry is defined according to a preset recommended temperature, e.g. 93° F., with a specified tolerance range of +/−X° F. A temperature control system is provided in the processor to keep the chemicals within the specified range.

Conventional processors usually include a film width sensor in the form of a reflective infrared sensor array adjacent a feed entrance opening, and may also include a feed detector in the form of a Hall effect switch or the like for detecting separation of entrance rollers due to the passage of film sheets at the front end of the transportation path. The film width sensor not only provides an indication of the width of a sheet entering the processor, but may also provide an indication of the occurrence of the leading edge and trailing edge of each sheet, since the signals from the film width sensor will change significantly as each leading and trailing edge is encountered. Information as to leading and trailing edge occurrences and width of the film, taken with prior knowledge of the constant transport speed, is used to keep track of cumulative total film surface area processed in order to guide chemistry replenishment control. The use of a separate entrance roller detector signals that a sheet of film has actually entered the nip of the first roller pair, and is not just sitting still on the film guide under the width sensor.

When sheets of film are sequentially fed into a processor, it is desirable that a spacing be maintained between the trailing edge of a first sheet and a leading edge of a next one in order to avoid overlap. The spacing should be enough so that overlap is avoided even though one or both of the sheets suffer some slippage and/or skewing along the transport path, but not so great that processing time is unduly affected. For a particular constant fixed transport speed processor, proper film spacing may be controlled by a fixed set time interval between the entry into the processor of the trailing edge of the first sheet and the time when the user is signalled to enter the next sheet. When the entry of the leading edge of the first sheet into the processor is detected, an annunciator in the form of a "wait" light is illuminated to signal that the required spacing has not yet been attained. At a set time after the entrance of the trailing edge into the processor has been detected, the "wait" light is extinguished and a "ready" light is illuminated.

Although conventional processors used for radiographic image processing are traditionally configured to operate at a constant film transport speed, modifications may be made through gear changes and the like to vary the process. Moreover, new processors are being introduced which are usable in more than one mode. The mode is often referred to in shorthand fashion by a nominal film transport "drop time", which may be defined as the time from entry of the leading edge of a sheet of film at the feed end until exit of the trailing edge of the same sheet of film at the discharge end. Conventional processors operate in standard (90 second), rapid (45 second), or "Kwik" (30 second) mode, and can be varied to operate in an extended-cycle mode, such as described in L. Taber & A. G. Hans, "Processing of Mammographic Films: Technical and Clinical Consideration," *Radiology*, Vol. 173, No. 1, pages 65-69, Oct. 1989. In the latter mode, processor speed is lowered and chemistry temperature is raised to enhance image contrast for better detection of changes in density of fibrous tissue. The new processors will be settable as to run parameters, including transport speed in order to be able to use the same processor for multiple processing modes.

It is desirable, in a processor having selectable transport speed, to be able to maintain a fixed interfilm spacing during transport regardless of the transport speed setting. Conventional systems that operate on a fixed time interval to determine film spacing are inadequate for this purpose. When faster transport speeds are selected, the same fixed time interval will give a spacing that is too great. When slower transport speeds are selected, the same interval will give a spacing that is too small.

One prior art arrangement, described in U.S. Pat. No. 4,300,828, sets spacing using a feed counter clocked by a drive shaft encoder. A microcomputer loads the feed counter with a number corresponding to the number of shaft encoder pulses needed to drive the trailing edge of the sheet past a particular point of the transport path. When the count reaches zero, a feed annunciator is actuated and a "wait" light is turned off. There is no teaching or recognition in the '828 patent of using such a shaft encoder system in a processor whose transport speed is settable. Moreover, the mechanical nature of the encoder limits programming flexibility.

SUMMARY OF THE INVENTION

It is an object of the present invention, in a processor utilizing a fixed time period between trailing edge of a first sheet and leading edge of a second sheet, to provide a system for varying the fixed time in response to variation in transport speed, so as to maintain a fixed interfilm spacing to avoid overlap regardless of film transport speed.

It is another object of the present invention to provide an annunciator to signal the attainment of recommended film sheet spacing in an automatic processor

configured to operate at a plurality of film transport speed settings.

In accordance with the invention, a processor of exposed photosensitive media having means for automatically transporting film along a path through developer, fixer, wash and dryer stations and means for monitoring the entrance of a trailing edge of a particular medium into the processor, further comprises means responsive to user input for setting system parameters including a desirable transport speed, and means for determining and signalling the passage from entrance of that trailing edge to the time to feed the next medium at a desired fixed optimum spacing.

In one aspect of the invention, described in greater detail below, processor film transport speed is set according to user selection of a processor operating mode, and annunciators in the form of "ready" and "wait" lights are controlled in accordance with a determination of lead time needed to assure maintenance of a desired linear spacing between successive sheets of film, for the particular processor mode setting. A microcomputer determines the number of clock counts to be loaded into a counter responsive to setting of the transport speed.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention have been chosen for purposes of illustration and description and are shown in the accompanying drawings, wherein:

FIG. **1** is a perspective view of a processor in which a fixed film spacing system in accordance with the present invention can be employed;

FIG. **2** is a schematic representation of relevant elements of the processor of FIG. **1**;

FIG. **3** is a fragmentary view of an entrance roller detector usable in the processor of FIGS. **1** and **2**;

FIG. **4** is a block diagram of the fixed film spacing system employed in the processor of FIGS. **1** and **2**; and

FIG. **5** is a flow diagram of the operation of the system of FIG. **4**.

Throughout the drawings, like elements are referred to by like numerals.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The principles of the invention are illustrated, by way of example, embodied in the form of a fixed film spacing system **10** (FIG. **4**) suitable for use with a processor **12** (FIGS. **1** and **2**) for the automatic processing of photosensitive media in the form of successive sheets of film F1, F2 (FIG. **2**), such as for the development of radiographic images for medical diagnostic purposes.

The processor **12** has a feed shelf **14** positioned ahead of an entrance opening **15** (FIG. **2**). The front end of the processor **12** including feed shelf **14** and entrance opening **15** is located in a darkroom to avoid unwanted exposure of the sheets F1, F2 fed into the processor **12**. The remaining portion of the processor **12** may be outside the darkroom. Sheets Fl, F2 entered through entrance opening **15** are transported through the processor **12** along a travel path **16** (indicated by arrows), and are eventually driven out of the back end of processor **12** into a catch bin **17** at an exit opening **18**.

The processor **12** includes a developing station comprising a tank **21** filled with developer chemical; a fixing station comprising a tank **22** filled with fixer chemical; and a wash station comprising a tank **23** filled with wash water or comprising some other appropriate film washing device. Processor **12** also includes a drying station **24** comprising oppositely-disposed pluralities of air dispensing tubes **25** or some other appropriate film drying mechanism.

Positioned proximate opening **15** is a sensor **26**, such as a conventional universal film detector board, reflective infrared sensor array which provides signals indicative of sheet width when a sheet F1, F2 is presented at the entrance opening **15**. The film width sensor **26** also provides an indication of the occurrence of passage of the leading edge and trailing edge of each sheet past point **26** of the processor **12**. A second sensor **27**, in the form of a magnetic reed switch **29** or the like (FIG. **3**), may be provided to detect separation of entrance rollers **28** to signal the beginning of transportation of a sheet of film along the path **16**. Sensor **27**, as shown, is a Hall effect sensor and has an actuator or slug **32** mounted on a rocker arm **36** for movement about a pivot pin **37**, from the solid line to the dot-dashed line position, in response to separation of the upper entrance roller **28***a* from the lower entrance roller **28***b*. Other sensors may also be used.

In FIG. **2**, the sheet path **16** is shown as defined by a plurality of film transport rollers **30** and a plurality of guide shoes **31** located to direct a sheet of film F sequentially through the tanks **21**, **22**, **23** and dryer **24**. The rollers **30** form the transport system for transporting the sheets F1, F2 through the processor **12**. Crossover assemblies act at the interfaces between the respective tanks **21**, **22**, **23** and dryer **24** to transport sheets between the corresponding stations. Rollers **30** may be driven in conventional manner by a common drive shaft **33** (FIG. **4**) having alternating right-hand and left-hand axially-spaced worms for driving adjacent columns of rollers **30** at the same speed in counterrotation, so as to move the sheets F1, F2 in the direction of the arrows along path **16**. Drive shaft **33** may be connected by a no slip chain drive and toothed sprockets (not shown) to be driven by an electric motor **34** such as, for example, a variable speed brushless DC motor.

The temperature of developer chemical in tank **21** may be controlled by means of a recirculation plumbing path **35** (FIG. **2**) having a pump P for drawing developer out of tank **21**, through a thermowell or other suitable heater and filter, and then passing it back to the tank **21**. A temperature sensor **37** (FIG. **4**) is provided in the tank **21** or recirculation path **35** to monitor the temperature of the developer. Developer temperature may be displayed on a meter **41** located on an exterior control panel **42** of the processor **12**. Temperature control of fixer chemistry may be conveniently provided by passing an immersed loop **39** through the fixer tank **22**.

FIG. **4** illustrates a control system usable in implementing an embodiment of the present invention. As shown in FIG. **4**, a microcomputer **43** is connected to direct the operation of the processor **12**. Microcomputer **43** receives manual input from the user through a mode switch **44** as to what processor mode of operation is desired. The system can be configured to enable the user to select among predesignated modes, such as standard, rapid, "Kwik," or extended modes having predetermined associated film path speed and chemistry temperature parameters; and can also be configured to permit a user to set a desired path speed and temperature directly. One way to implement mode switch **44** is by means of an alphanumeric keypad **45** and keypad display **46** (FIG. **1**) for providing programming communication between the user and the microcomputer **43**. For example, a function code can be entered to signal that

mode selection is being made, followed by a selection code to designate the selected mode. Alternatively, a function code can be entered for film path speed or chemistry temperature, followed by entry of a selected speed or temperature setting. Another way to implement switch **44** is by means of a plurality of push button or toggle switches, respectively dedicated one for each selectable mode, and which are selectively actuated by the user in accordance with user needs.

Microcomputer **43** is also connected to receive input information from the film width sensor **26**, the entrance roller sensor **27**, the developer temperature sensor **37** and, optionally, from a shaft speed sensor **48**. Shaft speed sensor **48**, which may comprise a shaft encoder mounted for rotation with drive shaft **33** and an associated encoder sensor, provides feedback information about the speed of the common shaft **33** that uniformly drives the transport rollers **30** (FIG. **2**). This gives the speed with which film is driven along the film transport path **16**. The width sensor **26** provides the microcomputer **43** with information on the leading and trailing edge occurrences and the width of the film sheets **F1**, **F2**. This can be used together with microprocessor set film speed or film speed measured by sensor **48** to give a cumulative film development area total to control chemistry replenishment. The entrance roller sensor **27** signals when a film sheet leading edge has been picked up by the roller path **16**, or when a trailing edge has passed a certain point in path **16**. This information can be used together with transport speed and known length of the path **16** from entrance rollers **28** to exit rollers **50** (FIG. **2**), to indicate when a sheet of film is present along the path **16**.

Microcomputer **43** is shown in FIG. **4** connected to motor control circuitry **51**, heater control circuitry **52**, and annunciator control circuitry **53**. Motor control circuitry **51** is connected to motor **34** to control the speed of rotation of drive shaft **33**. This controls the speed of travel of film sheets F1, F2 along the film path **16** and, thus, determines the length of time a sheet spends at each of the stations (viz. controls development time). Heater control circuitry **52** is connected to control the temperature of the developer flowing in the recirculation path **35** (FIG. **2**) and, thus, the temperature of developer in tank **21** and fixer in tank **22**. Annunciator control circuitry **53** is connected to annunciators in the form of "Wait" light **54** and "Ready" light **55** to control the on/off cycles of the same. Identical "Wait" and "Ready" lights **54**, **55** (for example, LED's) may be provided on both the darkroom (not shown) and lightroom (see control panel **42** in FIG. **1**) sides of the processor **12**.

In accordance with the invention, as indicated in the flow diagram of FIG. **5**, a user-designated mode change selected at keypad **45** (FIG. **1**) or other mode switch **44** (FIG. **4**) is input to microcomputer **43** (**100**) to cause a designation (through look-up table, algorithm or the like) of reference developer temperature and transport speed parameters recommended for the selected mode (**102**). Motor and heater control circuits **51**, **52** are then directed to control the motor and heater to bring the actual developer temperature and film path transport speed into line with the designated reference temperature and speed. The system can be configured, if desired, to permit the entry of a particular film transport speed directly. Selection of a new film transport speed, whether by mode designation or direct entry, will cause a designation of a new time delay period between trailing edge of a first sheet F1 and leading edge of a second sheet F2, needed to achieve a predetermined desired fixed spacing (**103**, **104**).

The time in seconds required between the trailing edge of a first sheet F1 and the leading edge of a second sheet F2 may, for example, be determined using the following algorithm:

$$\text{Time (secs)} = ((L/V) \times 60 \text{ secs/min})/100$$

where L=interfilm spacing in inches×100; and V=film velocity in inches/minute.

Using a desired linear sheet spacing of three inches, the delay time desired to maintain a constant linear separation between sheets F1, F2 along path **16** for different given transport speeds is as follows:

V (in/min)	time (secs)
30	6
40	4.5
50	3.6
60	3
70	2.57
80	2.25
90	2.0
100	1.8
110	1.63
120	1.5

The delay times can also be set using a preestablished look-up table.

When the sensors **26** and/or **27** detect the passage of the leading edge of a first sheet F1 into the processor **12** (**105**), annunciator control circuit **53** is directed by microcomputer **43** to turn the "wait" light **54** on, and the "ready" light **55** off (**106**). When the trailing edge of sheet F1 is detected (**107**), microcomputer **43** directs the loading of a counter **60** (FIG. **4**) with a number corresponding to the number of pulses of a system clock **61** needed to give the required sheet separation time in seconds determined in response to the selection of transport speed (**108**). When the count in counter **60** reaches zero (**109**, **110**), the "wait" light is turned off and the "ready" light turned on (**111**). This indicates to the user that the sheet F1 has passed a point where the next sheet F2 can be fed into the processor.

As shown in FIG. **5**, if counter **60** is not at zero, the "wait" light **54** remains on and the "ready" light **55** remains off (**109**). When the counter **60** reaches zero, the "wait" light **54** is then switched off and the "ready" light **55** is switched on (**111**).

Other annunciators, such as a buzzer **58**, can be connected to the microcomputer **43** to be actuated whenever counter **60** reaches zero to indicate a "ready" condition exists and a fresh sheet F2 can be fed in at entrance **15** (**112**).

Those skilled in the art to which the invention relates will appreciate that other substitutions and modifications can be made to the described embodiments without departing from the spirit and scope of the invention as described by the claims below.

What is claimed is:

1. In apparatus for the processing of exposed photosensitive media, said apparatus having means for automatically transporting said media from a feed point along a path through developer, fixer, wash and dryer stations in accordance with a set transport speed, means for monitoring the passage of a trailing edge of a partic-

ular medium past said feed point, and annunciator means for signalling a "ready" status for indicating when a next medium can be fed from said feed point along said path, after the trailing edge has advanced a fixed distance along said path, the improvement comprising:

said apparatus further including a timer comprising a system clock for generating pulses at constant time unit intervals independent of said means for transporting, and a counter connected to said clock for counting said pulses; a control panel; means responsive to user input at said control panel for selectively resetting said transport speed to a different transport speed; means, responsive to said selectively resetting means and said monitoring means, for automatically setting a number of said pulses to be counted by said counter, said number corresponding to the time in seconds needed for said trailing edge to advance by said fixed distance along said path at said different transport speed; and means, responsive to counting of said number of pulses by said counter, for controlling said annunciator means to signal the "ready" status when said trailing edge has advanced by said fixed distance along said path.

2. The improvement as in claim **1**, wherein said means for transporting comprises a plurality of transport rollers, a motor for driving said rollers, and a microprocessor circuit connected to said motor, said timer and said selectively resetting means for controlling said motor and said timer in accordance with said selectively reset transport speed.

3. The improvement as in claim **2**, wherein said annunciator means comprises at least one light.

4. The improvement as in claim **2**, wherein said apparatus is configured to operate at a specified one of a plurality of predefined transport speeds corresponding respectively to a plurality of operating modes, said means for resetting comprises means for selecting one of said modes and programming said microprocessor circuit according to the selected mode to control said timer and said motor in accordance with said one of said transport speeds corresponding to said selected mode.

5. The improvement as in claim **4**, wherein said means for selecting one of said modes comprises a mode switch and means for enabling user manual input to said mode switch.

6. The improvement as in claim **5**, wherein said means for enabling user input comprises a user operable keypad.

7. Apparatus for the processing of exposed photosensitive media, comprising:

a developer tank for the containment of developer;

user input means for selecting one of a plurality of operating modes;

means for automatically defining a transport speed in response to said selected operating mode;

means for automatically transporting successive sheets of said media from a feed point along a path through said developer tank in accordance with said defined transport speed;

means for sensing the passage of a trailing edge of a first of said sheets past said feed point;

a timer comprises a system clock for generating pulses at constant time unit intervals independent of said means for transporting, and a counter connected to said clock for counting said pulses;

an annunciator connected to said counter; and

means, responsive to said defined transport speed and said sensing means, for automatically setting a number of said pulses to be counted by said counter, said number corresponding to the time in seconds needed for said first sheet to travel a predetermined fixed distance along said path from said feed point at said defined transport speed; and means, responsive to counting of said number of pulses by said counter for controlling said annunciator to signal when said first sheet has travelled said predetermined fixed distance.

8. A method for automatically establishing a fixed minimum spacing between sheets of exposed photosensitive media transported along a path through developer, fixer, wash and dryer stations of a processor having means, including a motor, for automatically transporting successive ones of said sheets from a feed point along said path in accordance with a defined transport speed; means for sensing the passage of an edge of a first sheet past said feed point; a timer including a system clock for generating pulses at constant time unit intervals independent of said means for transporting, and a counter connected to said clock; and an annunciator connected to said timer; comprising the steps of:

defining a transport speed in response to user selection of one of a plurality of operating modes;

controlling said motor in accordance with said defined transport speed;

detecting passage of said edge of said first sheet past said feed point with said sensing means;

in response to detection of said edge of said first sheet, setting a number of pulses to be counted by said counter, said number corresponding to the time in seconds required for said edge traveling at said defined transport speed to travel said fixed minimum spacing;

counting pulses by said counter and delivering a timer signal when said number is reached; and

actuating an annunciator in response to said timer signal.

9. A method as in claim **8**, wherein said annunciator is a "wait" light, said sensing means detects said trailing edge, and said light is turned on at least when said first sheet trailing edge passes said feed point, and remains on until said first sheet trailing edge has travelled past said feed point by said fixed spacing.

10. A method as in claim **8**, wherein said annunciator is a "ready" light, said sensing means detects said trailing edge, and said light is turned off at least when said first sheet trailing edge passes said feed point, and remains off until said first sheet trailing edge has travelled past said feed point by said fixed spacing.

11. A method as in claim **8**, wherein said detecting step comprises detecting passage of said trailing edge.

12. A method as in claim **11**, wherein said defining, controlling, setting and actuating steps are performed at least partly by a microprocessor.

13. The improvement as in claim **4**, wherein said means for automatically setting said number comprises look-up table means addressable by said microprocessor for setting said number in response to said different transport speed.

14. A method as in claim **12**, wherein said number is set under control of said microprocessor, addressing a look-up table in accordance with said defined transport speed.

* * * * *